PALMQUIST

Electricity on Farms

Electrical Engineering

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# ELECTRICITY ON FARMS

BY

DAVID ROY PALMQUIST

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THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

ELECTRICAL ENGINEERING

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COLLEGE OF ENGINEERING
UNIVERSITY OF ILLINOIS
1911

UNIVERSITY OF ILLINOIS

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

David Roy Palmquist

ENTITLED Electricity on Farms

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Electrical Engineering

Instructor in Charge

APPROVED: Ernst J. Berg

HEAD OF DEPARTMENT OF Electrical Engineering

# ELECTRICITY ON FARMS.

## Purpose of the Thesis.

1. To show the progress that has been made in the use of electricity on farms.
2. To discuss the applications and the advantages of the electricity on farms.
3. To suggest ways in which electricity may be obtained by the farmer.
4. To point out the great possibilities of this undeveloped and profitable field.

# ELECTRICITY ON FARMS

The beginning of the twentieth century, also marks the beginning of the development of one of the largest fields for electricity. Engineers have been so interested in the perfection of electrical apparatus and the distribution of the power in the city districts, that they have entirely neglected the needs of the agriculturalist. The farmer has long known of the electric lamp, and has appreciated the adaptability, the cleanliness, and the convenience of this method of illumination, and would gladly adopt it if possible. The cry is heard from all sides about the scarcity and the high price of farm labor. There are two ways in which to meet this difficulty: (1) to secure a larger supply of labor; (2) to improve the equipment so that the present supply of labor can do more efficient work. The former is a sociological problem, but the latter can be solved by the farmer. By means of electricity, he may equip his farm so that one man is able to do the work of two.

Until recently, very little electric lighting has been attempted on the farm, chiefly because the means of obtaining the electric current in the rural districts were very inadequate. At present many of the small country towns are supplied with electricity from one central plant. This necessitates the running of transmission lines through the farm districts. Many farmers take advantage of this and use this source of energy for lighting and power purposes. In other parts of the country the trolley or interurban line is used as

a source of power; this method, however, is very unsatisfactory as the voltage may drop whenever a car starts up anywhere along the line, thus causing dim and unsteady lights. Another source of power which may be developed to a certain extent is the small stream. Under favorable circumstances this may be the cheapest source.

The possibilities of electricity as a source for general power are just commencing to be realized by the farmer. At present it is used mainly for the small power purposes, such as the running of washing machines, cream separators, electric flat-irons, etc. However, these more progressive farmers of to-day must install private generating plants, or obtain electricity from a central plant.

It has remained for the engineer to accomplish what the agriculturist has failed to do. He is establishing easy means of communication and transportation, devising conveniences for the farm home, and most of all, he is introducing electrical power to reduce the drudgery of the monotonous daily tasks. The agricultural world is awakening to the fact that after all, the farm is an engineering proposition. To make production efficient, it must be organized on the same lines as other industries. The small motor for power purposes and electric lighting are the beginning of a wonderful development in agricultural engineering, and have a greater significance than the number of present installations indicate. It is significant of the necessity to intensify agriculture by applying more power to each acre and the carrying processes of the farm. It means the elimination of drudgery, the saving of

unnecessary human exertion, which is conservation of the highest type. It means the opportunity for the exercise of mental rather than physical strength, the development of broader intelligence on the part of the farmer, with direct benefit to those who must depend upon the farmers' efficiency for their daily bread.

It is admitted by all, that the electric light is actually cheaper, cleaner, and more convenient than the kerosene lamp. The use of matches and the consequent fire risk, the annoyances of filling and caring for the lamps, the breakage of the chimneys and other parts, the prevalence of smoke and disagreeable odors, the vitiation of the air, inseparable from both the oil and the gas light, have all been eliminated by the electric light. Electric illumination of farms is practical to the lighting of the stables and barns. The use of lanterns in and about the barns and all similar places has been the cause of numerous fires and the destruction of millions of dollars worth of property, as it is seldom that the country home has available apparatus for successful fighting of fires.

The rapid progress made in electric lighting has entirely changed the aspect of the problem of small lighting plants. The tungsten incandescent lamp, introduced several years ago, and now so universally used, is the latest and the highest development of the lamp makers' art and gives a fine light of unequaled brilliancy. This lamp has made it possible to obtain the same amount of illumination formerly afforded by the ordinary carbon filament lamp with about one-third the amount of electricity. Commercially, electric energy is

measured by the kilowatt hour, one kilowatt is about 30 per cent greater than one horse power, and is equal to 1000 watts. The 16 candle power carbon lamp requires about 50 watts or one-twentieth of a kilowatt. The tungsten lamp for the same amount of light requires only 20 watts or one-fiftieth of a kilowatt. When a private plant is used, storage batteries must be installed in connection with it. The capacity of these batteries is measured in kilowatt hours. Consequently when the tungsten lamp is used with a private plant, a much smaller storage battery is required than with the carbon lamp. These lamps are made for all standard voltages, but for the farmer, who having his generating station, the 25 or 30 volt lamp is undoubtedly the most economical. Lamps of these voltages are made with intensities ranging from 4 to 20 candle power, requiring from 5 to 25 watts of energy for operation.

While the American farmer has applied his power about the house and barn only, the German farmer has gone a step further and applied power to the fields as well. The "Electrical Review and Western Electrician" says in this connection: "While the United States has developed and led the world in the pioneering of many classes of electrical inventions, (such as the making of arc lamps, incandescent lamps, telephone, and electric railways), it is not doing so when it comes to the utilizing of electric power for agriculture. Here and there we find progressive farmers equiping their homes and barns with both electric light and power, but this country is far behind Germany". The reason for this is a three-fold one, lying partly in the smaller size of the average German

farm which makes it more accessible for intensive cultivation. Another reason is the nearness of the average German farm to some town having an electric light plant from which the current can be purchased without requiring the farmer to install a generating plant of his own. The third reason is that the labor problem seems to have been even more serious in Germany than in some parts of the United States.

Aside from the saving in the cost of planting, tilling, and the harvesting of the crops, the use of machinery on the farms partly solves the difficulty of procuring farm helpers, who have been steadily growing more scarce in Germany. The reason for the scarcity of farm labor is not far to seek for statistics show that while the population of Germany has increased about 58 per cent the last 30 years, the exodus from the rural districts to the larger cities of Germany and to American has left the number of farm workers even smaller than it was thirty years ago. Of course the demand for farm products has grown with the population and fortunately the more modern methods of sowing and cultivating have increased the productivity of the soil so that the German farmers can hold their own with the increased demand for crops, provided that they can procure the needed power either from the laborers or from the machinery. Thus government statistics show that the present methods, as already adopted in Germany, have increased productiveness per acre 75 per cent for potatoes, 63 percnnt for rye, and 52 per cent for wheat, making an average gain ahead of the increase in population during the last 30 years. Raising and harvesting these larger crops has

required a large number of foreign farm helpers, the number employed during 1908, being 314,000. While these foreigners are only paid about two marks (47 cents) per day, they are frugal, and their savings are generally sent out of the country; hence the government is encouraging the use of machinery or equipments that will reduce the needed number of such imported helpers.

The indoor electric devices used on the up-to-date German farms consists of food choppers, grain cleaners, milking machines, pumps, cream separators, and the like. But in addition to these, the accessibility of the overhead wires has led to the successful use of electricity driven field machinery, much of which is new to American practice. Incidently, it is threatening to crowd out the costliest of our out-door implements, the steam driven threshing machine. This cannot safely be used indoors as the sparks from the furnace or the smoke stack would make a too serious fire risk; indeed, the German insurance regulations require such a steam "Locomobile" to be kept at least 32 feet from a barn. The fire risk can easily be negligible with a properly installed electric thresher which can be placed indoors so as to be used on rainy days, and as there is no time lost in firing up, the available helpers can utilize it the moment the rain starts. The greater uniformity of speed of the electrical driving also increases the output of the thresher in salable grain over that obtained by the steam or horse power, the efficiency or difference being from 3 to 10 per cent over these and 15 to 20 per cent over the flail threshing of olden times.

Another novel piece of equipment is the electric plow, a worthy successor to the steam plow of which 3000 are already in use in Germany. The steam plow has the advantage of being a self-propellor while its electric rival has to be drawn to the field; however, the latter weighs fully a third less than the steam plow, and hence does not pack the soil so tightly. It requires no hauling of fuel or water; can be drawn over the roads, bridges, and fields for which a steam plow is too heavy, and requires neither a skilled attendant nor frequent cleaning and repairs. Moreover, it can be used on hillsides where the tilting of the steam plow would tip one edge of the fire-box clear off the water, thus encouraging explosions. The electric plow usually consists of a double-ended plow mounted on wheels and drawn back and forth across the field by a wire rope attached to an electric motor. The same rope can be attached to a cultivator or a harrow, thus increasing the utility of the equipment and decreasing the use of horses. The difference in the cost of the plowing was recently stated by Harold Wallen (in a lecture before the German Electrochemical Society at Brannschweig) to be as the following:

| | Per hour | Per acre. |
|---|---|---|
| Horse drawn plow | $2.60 | $1.30 |
| Steam plow | $3.28 | $1.64 |
| Duples Electric plow | $2.36 | $1.18 |
| Simple Electric plow | $2.10 | $1.05 |

"Still another labor and horse saver that is being tried with success in Germany is a private trolley road for

transporting the crops from the fields to the barns and from the latter to the nearest railroad point, and also for the hauling of the fertilizer and seed. Such railways are usually of narrow gauge, similar to the so-called industrial railways used in and around the large manufacturing plants and are augmented by portable sections of track for extending the road to different portions of the field. In one instance it was found that with a farm of 2,000 acres located two miles from the nearest railroad, the installation of electric plows and of a narrow gauge trolley line did away with 31 out of 47 horses, and also with 15 men. The increased speed of the hauling of the crops is an important factor in making such a railway pay for itself and the same holds true of electric hay loaders and fodder hoists as are also used to certain extent".

At present time there are in Germany, three main "Overland Central Stations" as the Germans call them. They are, Lottin, Bebwitz, also Birnbaum, Meseritz and Schwerin. An "Overland Central Station" is an electric light company supplying a number of cities not far from each other, but with farm lands intervening, to which current can be supplied at a fair profit for the electric lighting company, and at a decided saving in time and labor for the progressive farmers. Of course, the transmission of the current from one city to another is at a high voltage, which cannot be used with safety until transformed to a low potential. This is usually done for the city purposes by transformers located in sub-stations or mounted on poles, but the scattering of transformers over a large farm would be too expensive. To overcome the cost, the Ger-

man transformer is mounted on a little wagon, from which poles can make contact with the wires at various parts of the field, while the low voltage is led through an insulated cable to a motor.

I will endeavor to describe briefly the "Overland Central Station" of Lottin, which has a water power of 300 horse power, and a reserve steam engine power of 100 horse power, and serves 61 agricultural industries, and 5 urban districts with 41200 acres of land with the current. The transmission line is 137 kilometers long and incloses an area of 270 square kilometers. The number of consumers on the line is 102, who use 150 motors with a total horse power of 1115 and 5000 incandescent lamps. Table (1) is interesting because it shows the consumption of electricity in the various industries.

Overland Stations.

Table 1.

| | Motors | | No. of Lights | |
|---|---|---|---|---|
| | No. | H.P. | Incan. | Arc. |
| Agricultural work or cultivation. | | | | |
| 6 with 2-3000 acres under plow | 41 | 274-1/2 | 1219 | 7 |
| 9 with 1-2000 acres under plow | 31 | 234-3/4 | 591 | 1 |
| 12 with 500-1000 acres under plow | 20 | 152 | 519 | 1 |
| 15 with 100-500 acres under plow | 21 | 166 | 324 | |
| 8 with and under 100 under plow | 8 | 24 | 66 | |
| Industrical work. | | | | |
| 4 Flour mills | 5 | 105 | | |
| 1 Saw mill | 1 | 20 | | |
| 1 Tile factory | 1 | 40 | | |
| 4 Cartwright machinery | 4 | 16 | | |
| 1 Forge | 1 | 3 | | |
| 2 Joineries | 2 | 7 | | |
| 1 Turning lathe | 1 | 1 | | |
| 2 Carpenter shops | 2 | 30 | | |
| 2 Soda water factories | 2 | 3-1/2 | | |
| 1 Distillery | 1 | 10 | | |
| 4 Butcher shops | 4 | 10 | | |
| 1 Machine shop | 1 | 5 | | |
| 1 Corn dealer | 1 | 3 | | |
| 1 Dairy Fram | 1 | 15 | | |
| 2 Pumping stations | 2 | 4 | | |
| 20 light consumers | | | 343 | 5 |
| 1 Railway station | | | 20 | |

| | Motors | | No. of Lights | |
|---|---|---|---|---|
| | No. | H.P. | Incan. | Arc |
| 1 Club house | | | 72 | 6 |
| 2 Towns | | | 1692 | -- |
| Total 102 | 150 | 1115-3/4 | 4846 | 20 |

Table 2 shows the amount of power required to thresh the different kinds of grains.

| Kinds of Grain. | Cwt. per A. | Grain wt. in percent of total weight | K.W. per cwt. of Salable Grain without straw press. | with press |
|---|---|---|---|---|
| Rye | 9 | 25 | .60 to .75 | .70 to .90 |
| | 12 | 35 | .45 to .55 | .50 to .65 |
| Wheat | 10 | 30 | .50 to .65 | .60 to .75 |
| | 14 | 40 | .40 to .50 | .45 to .60 |
| Oats | 9 | 40 | .40 to .50 | .45 to .55 |
| | 13 | 50 | .30 to .40 | .35 to .45 |
| Barley | 10 | 35 | .45 to .55 | .50 to .65 |
| | 15 | 45 | .35 to .45 | .40 to .55 |

Table 3 is a comparison between the operation of various machines by animal and mechanical power as used in Germany. It shows clearly the saving in mechanical operation over that of animals.

| | Grain Cleaners | | Feed Grinders | | Manure Spreader | | Threshing | | Beet Curring | | Pumping Water | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hr. | Cwt. | das. | cwt. | hrs. | cwt. | das. | cwt. | hrs. | cwt. | min. | Meters |
| Machine | 1 | 20 | 1 | 3 | 1 | 6 | 1 | 60 | 1 | 30 | 20 | 1.5 |
| Animal | 1 | 25 | 1 | 5 | 1 | 20 | 1 | 75 | 1 | 15 | 6 | 1.5 |

Electricity is not only economical in that it reduces expenses, but also because its applications are many and varied.

One of the most important factors, with which the farmer of the future will have to contend is the obtaining of this power. Here is a chance for the electrical engineer to come to his aid, which no doubt he will do in the near future. The extent of the applications of power to practical purposes on the farm is very broad. Farm machinery requiring power may be divided into three classes, according to the amount of power required.

(1) Cream separators, washing machines, bottle washers, grindstones, etc.

(2) Feed grinders, corn shellers, silage cutters, etc.

(3) Threshing machines, farm trucks, electric plows, etc.

The amount of power required to operate many of these is small. The presence of a plant of sufficient capacity to operate one or two of the larger machines often makes it poss-

ible to use the power for many of the other purposes requiring less power. The amount of work that a small amount of power will do can be judged from the following brief statements by David R. Cooper, Engineering Secretary of the State Water Supply Commission of New York; of what is actually being done.

"Six horse power will drive a grain separator and thresh 2500 bushels of oats in ten hours.

Three horse power furnishes all power needed to make 6000 pounds of milk into cheeses in one day.

Six horse power will run a feed mill grinding 20 bushels of feed, or ten to twelve bushels of ear corn, an hour.

Seven horse power drives an eighteen-inch separator, burr mill and the corn and cobb crusher, and corn sheller from twelve to fifteen bushels of feed an hour, and five to eight bushels of good fine meal.

Six horse power runs a heavy apple grater, grinding and pressing 200 to 250 bushels of apples to the hour.

Five horse power will drive a thirty inch circular saw, sawing from fifty to seventyfive cords of stove wood from hard oak in ten hours.

Six horse power saws all the wood four men can pile in cords.

Twelve horse power will run a sixteen inch silage cutter and the blower, and elevate the silage into a silo thirty feet high at the rate of ten tons per hour.

One horse power will pump from a well of ordinary depth in sufficient amount to supply the ordinary home and all

of the buildings with water for the ordinary uses.

The following table will give perhaps a more definite idea, what it takes to run the various machines".

| | |
|---|---|
| Cream separator | 1/2 to 4 horse power. |
| Milking machine | 3 to 5 " " |
| Grindstone | 1/2 to 1 " " |
| Bottle Washer | 1/2 to 1 " " |
| Water pump | 1 to 10 " " |
| Shredder | 10 to 15 " " |
| Silage grinder | 10 to 20 " " |
| Feed Grinder | 5 to 10 " " |
| Threshing | 10 to 20 " " |
| Wood saw | 3 to 5 " " |
| Corn sheller | 1 to 4 " " |
| Hay press | 4 to 25 " " |
| Refrigerator | 1/2 to 25 " " |

The following photographs show some of the machines, which are operated by the motors on the farms.

Corn sheller and a corn grinder driven by a motor which is situated overhead.

Corn elevator, operated by a three horse power motor.

Five farm machines belted to one shaft, which is driven by a motor.

Another aid to agriculture, to which electrical power may be supplied is irrigation. The arid and semi-arid regions of the United States comprise some 600,000,000 acres, and it is estimated that 100,000,000 acres of this area can be brought under cultivation by the several systems of irrigation.

In Colorado electricity is used to a great extent in irrigation. Pumping begins early in the spring, but not a great deal of it is done before the months of May and June. Potatoes are not irrigated until the latter part of July, and as a great portion of the acreage is covered by the Northern Colorado Power Company's lines devoted to this crop, the water irrigating of potatoes is used from about July 25th until September 10th, and the pumps are run almost continually during this period. The load upon the motor operating the pump is constant and the load factor of the lines supplying the energy to these pumps is almost 100 per cent during this time. A single farm is irrigated with a plant of from 10 to 30 horse power, and as each pump is usually of a size to give the motor full load, it is evident that a large number of kilowatt hours will be used by each unit. For such crops as sugar beets and grains, the pumps are operated less continually, but there is a longer season for them.

The rate charged by the Northern Power Company is 3 cents per kilowatt hour with a flat charge of $1 per rated horse power. By the Eaton Electric Company which secures its energy from the Northern Colorado Company, a rate of 3 and 1/2 cents per kilowatt hour is charged, with a flat rate of 50 cents per motor horse power per month. With both companies

the monthly charges cease when the irrigation season is closed.

The water to supply the pumps is secured most frequently from the irrigating ditches that run through valuable land, just as much of which may lie above the ditches as below. It is odd indeed to see a magnificant farm on the lower side of an irrigating ditch and a desert waste on the upper, with only a 10 foot ditch separating them. It is to make valuable land out of these dry stretches that electric irrigation is used.

The cost of attendance for the motor operated irrigating plant may be considered as negligible. The men who attend to the distribution of the water after it has been pumped into the ditch can readily start and stop the motor, and aside from this and filling the oil or grease cup on the stuffing box of the pump once in a while, no personal attention whatever is required. Many of the plants are operated continually, night and day during the height of the season, the water being set to the flow in certain places at night-fall and left to run through the night without any attention whatever. Many of the pumps of the Northern Company's lines were run for several weeks without stopping. The cost of maintenance is also negligible. So far as is known there were no repairs whatever required upon any of the lines with the sole exception of one motor and compensator that were burned out through carelessness. It is intereating to note that nearly 250,000 bushels of potatoes were produced upon 125 acres irrigated, the value of which exceeded several times the total cost of the pumping plant. This land had never been irrigated before, and a few years ago

cattle were running over these lands that now sell for nearly $100 per acre.

Where water power is not available, there are two ways of obtaining electricity on farms. These are by the means of the Central Station and by means of the Isolated Plant. Recently, I took occasion to investigate the system at Elmwood, Illinois. The Elmwood Electric Light Company is one of the pioneer central station companies to place the electric service at the hands of the farmer. This company supplies electricity to six small towns within a radius of twenty miles. This necessitates the running of high voltage transmission lines to each of these towns from the central station. The voltage on these lines is 6600 volts, with the exception of one, which is 13,000. The country penetrated by these lines is of unusual agricultural wealth, and the farmers have been quick to realize this source of power at their doors.

The step down transformers are used to reduce the high voltage to 2200 or 1100, at which voltage it is brought to the farmers yard, where it is reduced to 110 volts for lighting purposes by a one kilowatt transformer. Wherever there are groups of farmers within reasonable distances, branch lines are run out from the main transmission lines. In some instances these branch lines will supply as many as eight farms. Any farmer, living within three quarters of a mile from the main line may be supplied with electricity providing he pays $1 per pole, and assists by hauling the material for the extension, boarding the men or paying $10 to $15, according to the condition justifying the company. Such installation is done under

the supervision of the company, and all apparatus is furnished by them which costs the farmer about $50, which includes the meters and transformer. The houses are wired at cost, which is about $1 per light.

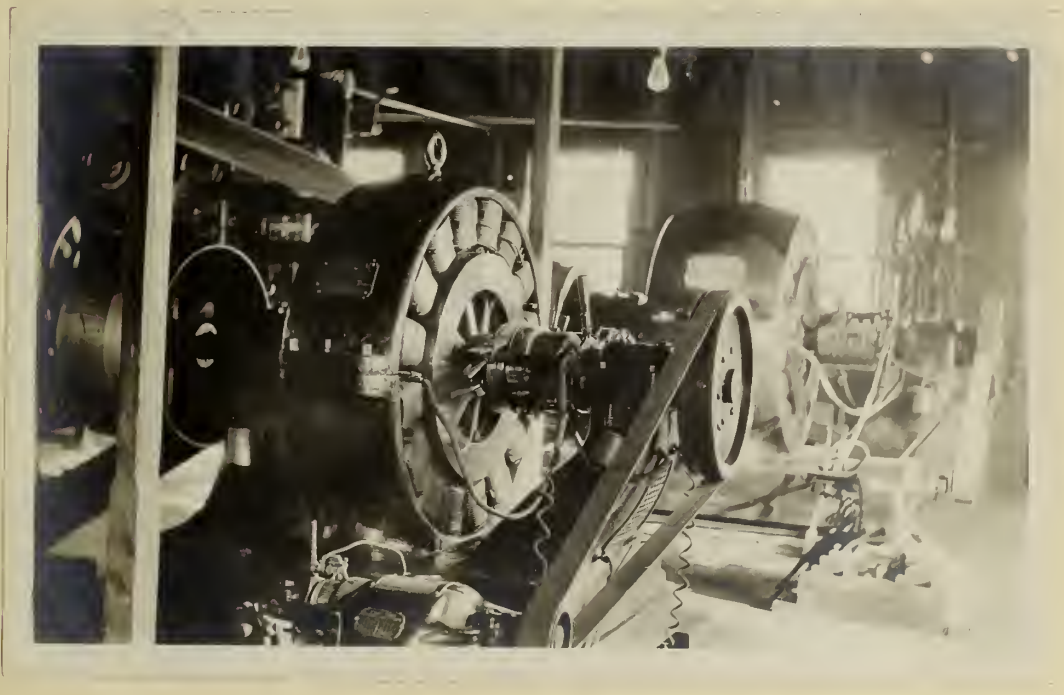
The Elmwood Company supplies all its consumers with electrical energy at a cheaper rate than it can be obtained from the cities. The rate is 10 cents per kilowatt hour, with a minimum charge for each month's service of $1 in the towns and $2 among the farmers. This extra minimum charge imposed on the farmers is justifiable on account of the additional cost of reaching the farmer customers.

The farmer is not at all reluctant about the installing of lights, as the average farmer at Elmwood has from 20 to 40 lights in the house, porch, stable, and sheds.

Besides using the electrical energy for lighting, the farmer operates motors, cream separators, washing machines, pumps, electric flat-irons, and feed grinders. Among the farmer customers, the meters are read and collections made every two months by a representative of the company, who uses an automobile in nice weather and a horse when the roads are in bad condition. Extra fuse plugs and lamps are in the hands of the farmers, who are generally quite competent to remedy all minor troubles. Emergency calls may be sent in over the telephone, to which the trouble man responds; however, such calls are very rare.

The farmers of Elmwood are a very good paying class of current users, their monthly bills ranging from $2 to $3. The average farm owner uses more electricity each month than the

town dweller in similar circumstances. No efforts have been made by the Elmwood Company to obtain present farmer customers, for the damand for its service has always exceeded the extent of the lines. As each farmer hears of his neighbor's improved lighting conveniences, he also applies for the services, and many requests have been received from the residents at uneconomical distances from the lighting lines. The following photographs show some of the installations on the Elmwood system, and methods of installing.



Interior view of Elmwood Electric Company's Power Plant.

6600 volt transmission line run along a railroad's right of way, to avoid the trimming of the trees, which is often necessary along highways.

Step-down transformer that supplies eight farms.

A typical installation for the farmer on the Elmwood system.

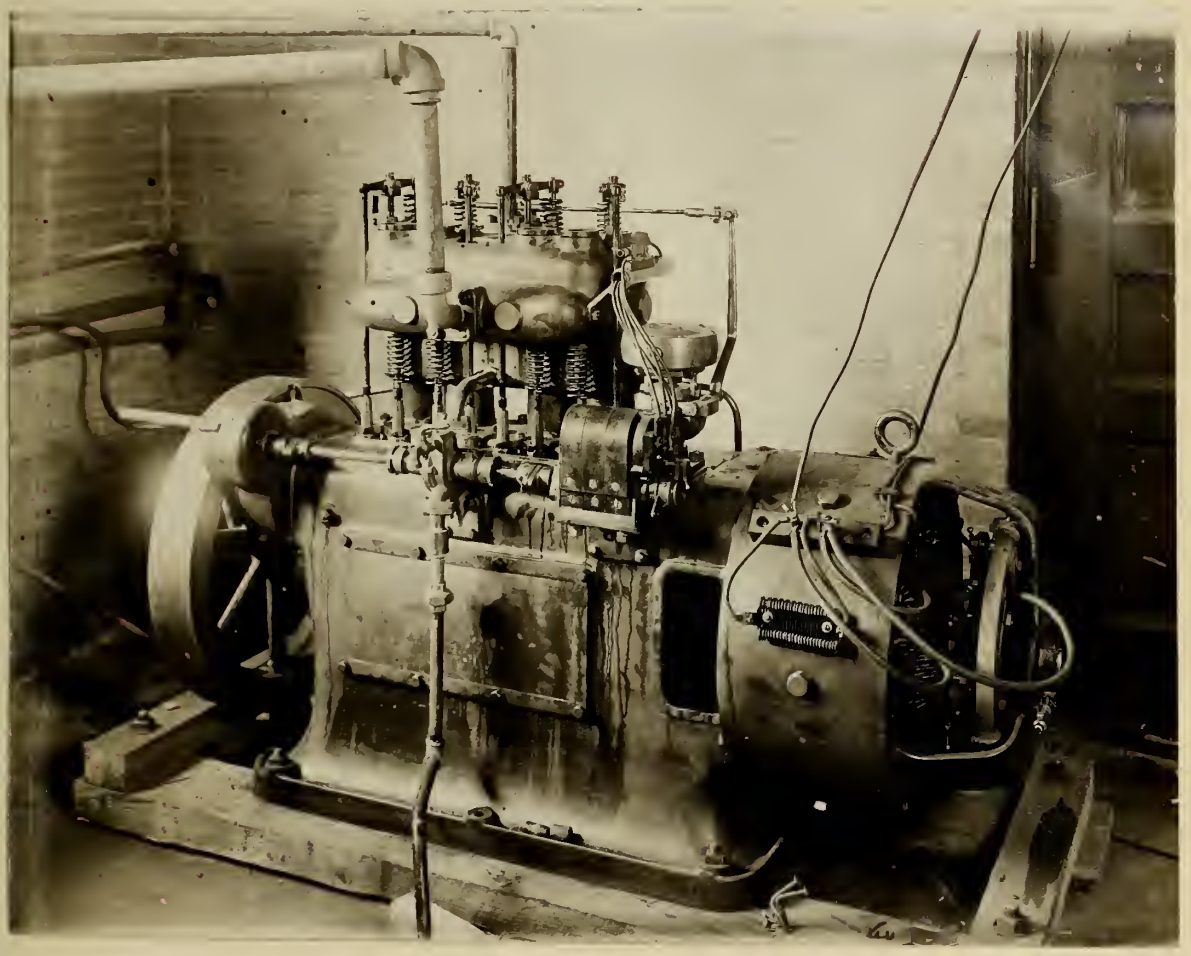
Farmer's installation.

Farmer's installation.

Pump operated by a 1/8 horse power motor.

Wash machine and cream separator operated by a 1/8 horse power motor.

Where electricity from the central station is not available the farmer must resort to the Isolated plant. This consists of a gasoline engine, generator, storage battery, and a switch board.



A typical farmers gasoline generating outfit.

The last photograph shows a farmer's typical gasoline generating outfit. Its rated output is 5 kilowatts at 125 volts. The engine is a 4 cylinder, 4 cycle gasoline engine, which runs at 750 R. P. M., and is of the throttling type. It is almost impossible to make a steady light with the "hit and miss" engine, or with a single cylinder engine, so that today all electric lighting giving satisfactory service are of the throttling type, and have two or more cylinders. The voltage regulation with this engine is exceptionally good, which is the main thing to be desired in an outfit of this kind. The engine is directly connected with the generator, thus having several advantages over the belt connected. First, compactness, which enables it to be placed in a very small space. Second, the direct connected outfit gives from 6 to 10 per cent more power, since there is no belt strain and the friction on the bearings of the engine and the dynamo. This also has a tendency to make the outfit longer lived, as it saves wear on both the engine and the dynamo shafts.

The generator is compounded so as to generate 120 volts at no load and 125 volts at full load. Usually in isolated plants the engine and generator capacity is sufficient for the total number of lamps connected, although they are all seldom in use at one time, consequently the plant operates at only partial load during the total lighting hours. This means low efficiency, poor regulation and high fuel costs. The installation of a storage battery corrects this weakness by permitting the operation of the generator at the full or the most economical load for a few hours, then shutting down entirely,

the battery providing the current for the balance of the time. In many cases it can be so arranged that the generator need be operated only every second or third day, and then at the most convenient time.

Furthermore, no additional labor is required, in fact, this cost is usually lessened, while the fuel cost and the maintenance and the repair is much reduced.

By taking the current directly from the battery, steady lights are obtained and the noise of the engine is avoided at night.

When on special occasions unusual lighting is required, the battery may be discharged in parallel with the generator, and demands equal to the combined capacity of the battery and the generator may be supplied.

The generating equipment may be stopped at any time for adjustment or repair without interrupting the service, the battery being available for the unexpected demand for power.

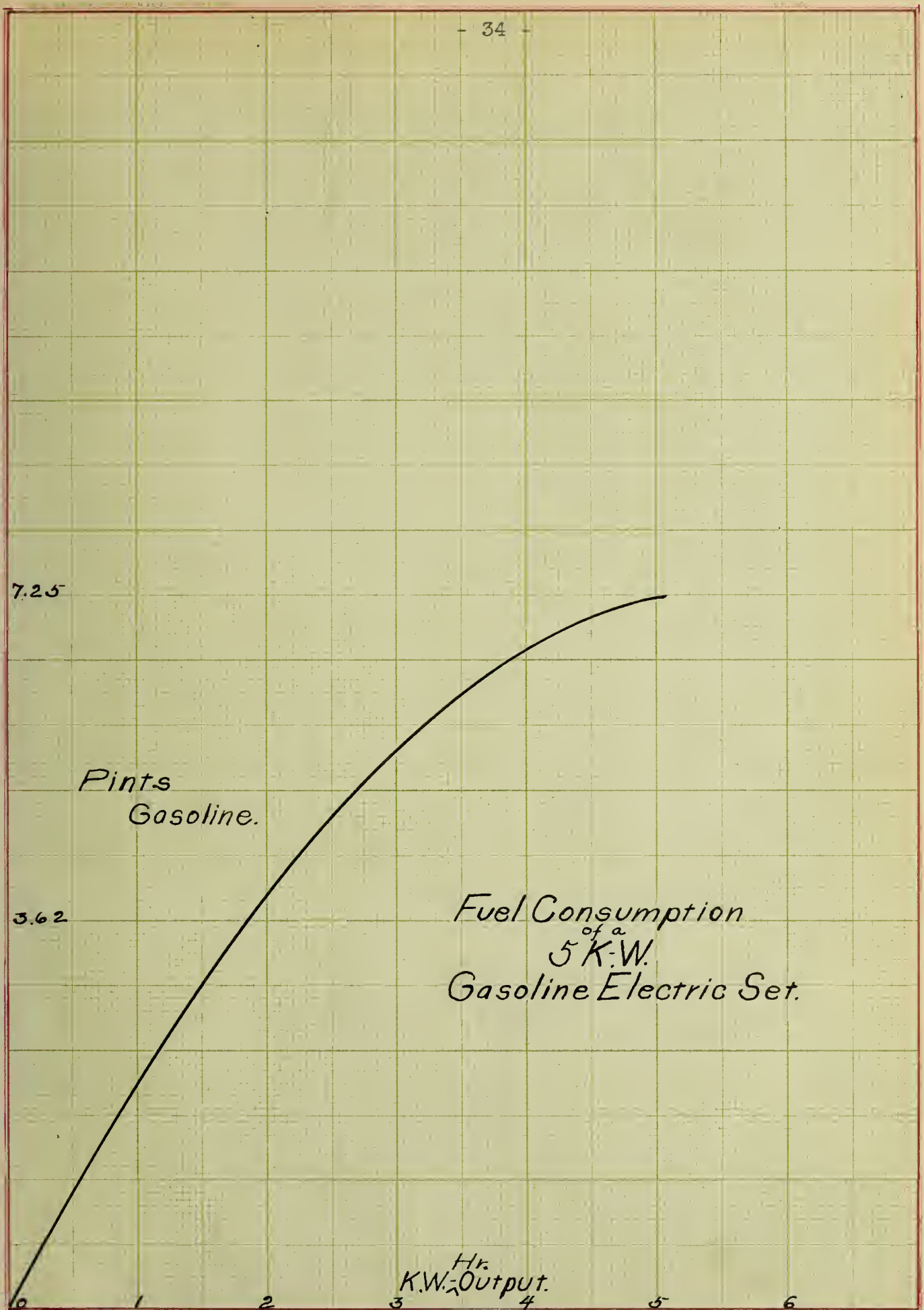
There are on the market today, two distinct generating outfits, namely, the low voltage and the high voltage plants. By low voltage, is meant outfits that generate from 20 to 40 volts, and the high voltage outfits are those that generate from 110 to 125 volts. Both outfits have their advantages and disadvantages. The advantages of the 30 volt system over the 125 is: (1) The smallest 125 volt tungsten lamp is 20 candle power, consuming 25 watts, while lamps of 16 candle power consuming 20, and the 12 candle power consuming 15 watts may be obtained of the 30 volt outfits. The advantage therein lies in the fact, that in several places 12 candle power lamps

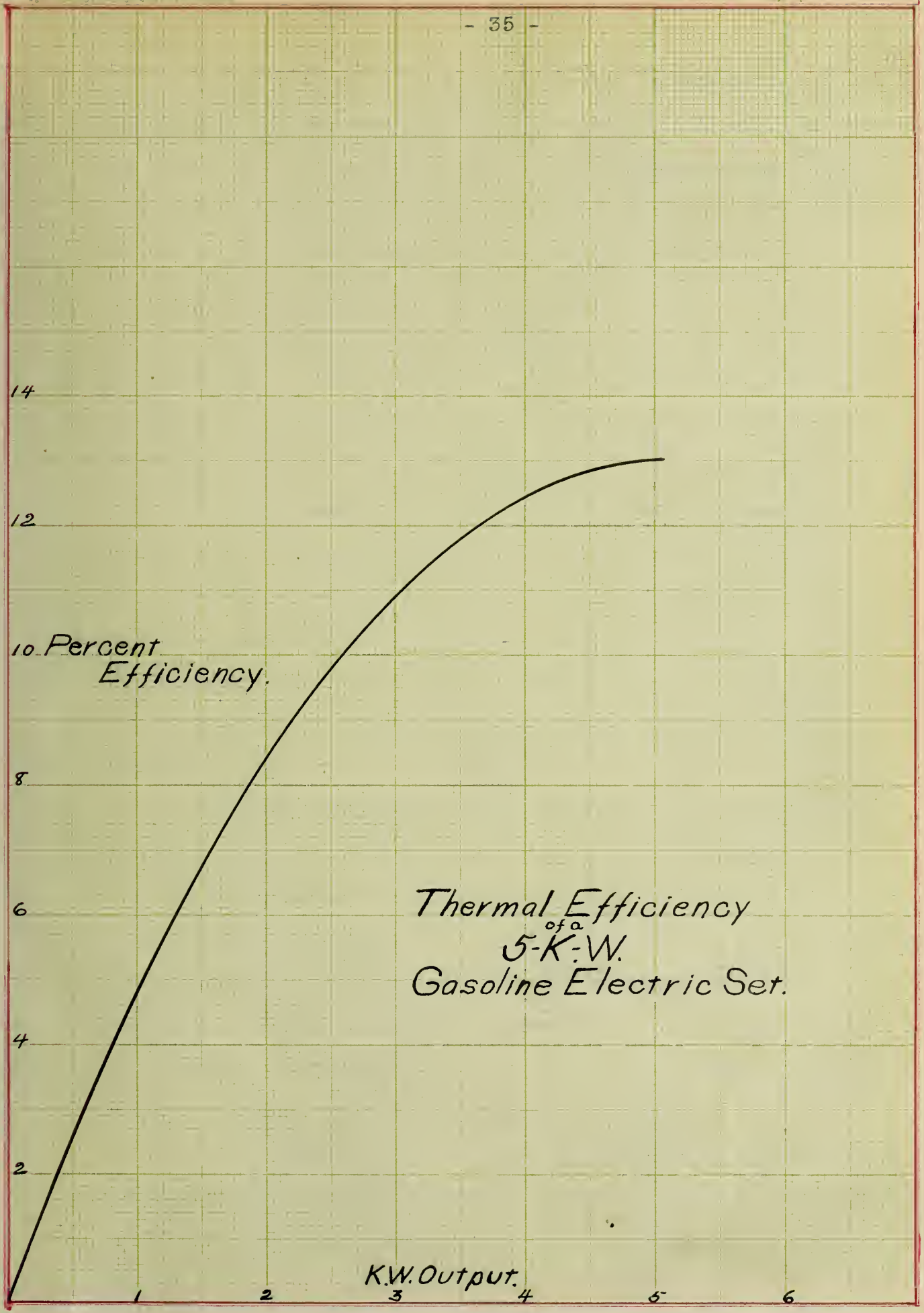
are sufficient, therefore, a greater number of lamps may be used; (2) The line loss is more appreciable at the low voltages than at the high voltages. If the electric current is to be used for the lighting only, the low voltage outfit is in all probabilities the best.

Since there are many uses to which electricity may be applied besides lighting, that are of equal, if not greater importance, we must consider the inability to procure appliances suitable for the low voltages. All appliances operated by electricity may be readily obtained in voltages of 100 to 125, whether vacuum cleaners, flat-irons, pumps, fans, etc. None of these articles are regularly made so as to be adapted for 30 volts. It might be well then to consider this phase of the situation before installing an electric light plant.

When the electric current must be transmitted a considerable distance from the generating plant, even the 125 volt outfit is often inadequate, since the loss is too great. For the outfit of this kind a special generator must be designed, from which a 125 D. C. voltage may be obtained to be used in connection with the storage battery, and a higher A. C. voltage which can be transmitted for the more distant power purposes.

The following figures show the thermal efficiency and the fuel consumption of a 5 kilowatt, 125 volt gasoline electric set. If we figure the gasoline worth 12 cents per gallon, the cost per kilowatt hour will be 2.17 cents.


7.25
Pints
Gasoline.
3.62
Fuel Consumption
of a
5 K.W.
Gasoline Electric Set.
Hr.
K.W. Output.
0
1
2
3
4
5
6


14
12
10
8
6
4
2
Percent
Efficiency.
Thermal Efficiency
of a
5-K.W.
Gasoline Electric Set.
K.W. Output.
1
2
3
4
5
6

The possibilities for an extensive use of electricity on farms is indeed great, to say the least. In the first place the field is a great one, since according to the last census only 33 per cent of the total population of the Unided States were situated so that they could obtain electricity from the Central Station. The time will eventually come in the United States when unified electric systems covering large territories will be built. Only by covering the country with electric circuits for the serving of the large groups of cities and villages from relatively large power houses, is it possible to serve rural districts generally with electric light and power at reasonable cost. Water power will be the main source of power for these systems, on account of the cheapness by which it may be obtained. In Germany electricity is supplied to the farmers from these systems, at a nominal price of three cents per kilowatt hour for the power and seven cents per kilowatt hour for lighting.

It is the larger farm proposition that offers the greater opportunity for the application of electricity, for not only are the various domestic conveniences desired, but in the farming operations there is a real opportunity to increase the rate of output and decrease the amount of labor involved in the producing of the crops, transporting labor and the materials in the fields and buildings, plowing, threshing, silage making, milking, pumping, refrigerating, and incubating.

With the equipment producing the most modern method of accomplishing all the operations that go to make up the routine of a grain, dairy, or a stock farm, the owner can afford

to employ all skilled labor, and just as much of it as he can provide productive work for, because in this way the profits will be greater through the increased output and the fields will have to be stimulated to their utmost to produce the material necessary to keep the machines up to a full operation period.

The keynote then becomes reliability of operation. This means adherence to a definite schedule of work, the substitution of more capable labor in the place of the unskilled farm worker, and the adoption of highly efficient mechanical devices which will eliminate, either wholly or in part, the manual labor, and accomplish in a given time the results that before their introduction would have seemed amazing.

It is no longer a matter of prophecy to say that electricity on the farms will do these things; for it has been proved, and every day the ways in which this great force may be used to an advantage are becoming more and more numerous. The saving in the cost of labor makes it of the greatest importance to the farmer.

The important applications of electricity on the farm have been pretty well described and demonstrated in agricultural experiments. The salient points which have been brought out by these demonstrations being:

(1) Electric lighting and the motor drive for all extensive field and barn operations is feasible with the apparatus now to be found in the commercial market of today.

(2) By the adoption of one system for transmitting, utilizing, and controlling the energy required for both light

and power, as is possible only with electricity, an organization of equipment is provided that cannot even be approached by the combination of any other means.

(3) The use of electric power as a substitute for the individual engines often installed in barns and out-buildings has the advantage of the greater reliability, safety, cleanliness, and flexibility in application.

(4) The expense of electric wiring and motor equipments are not excessive as compared with the costs of other equipments.

(5) The installation of electric apparatus on the farm will pay for itself in the saving over the old method in the first season.

(6) The economy of the proposition is the strongest argument.